Test March 8th

Half-life, $t_{1/2}$

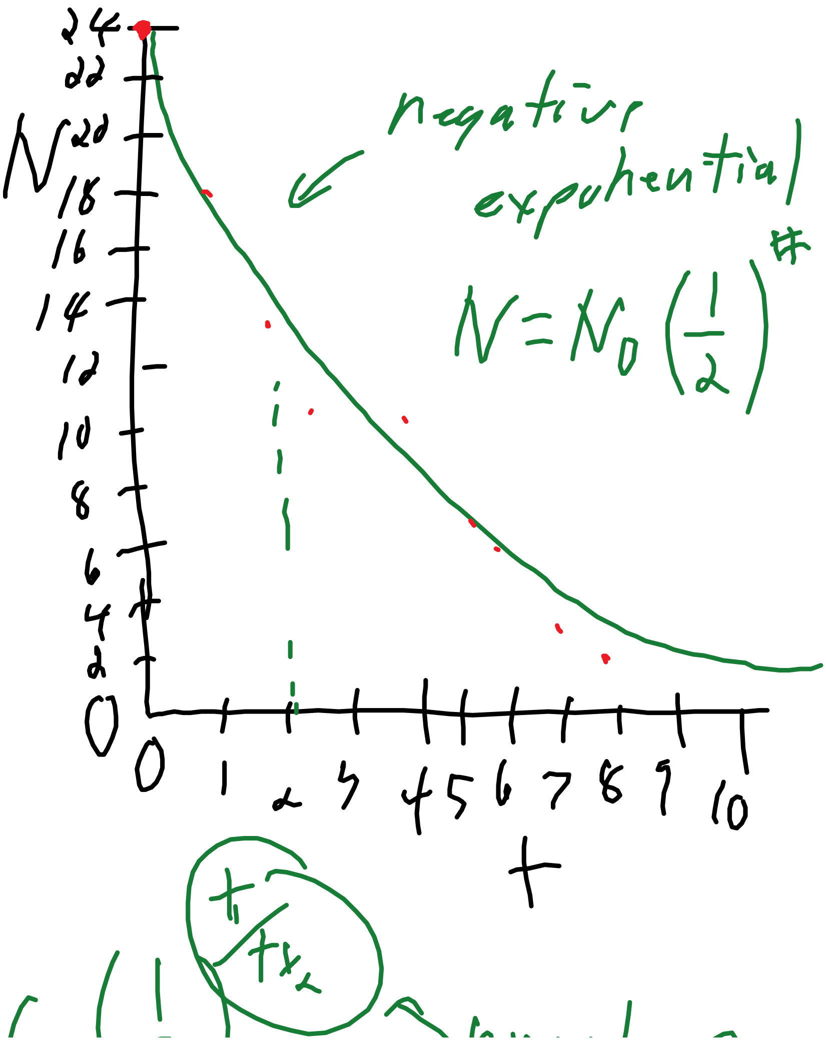
Model of Radioactive Half-life.
Everyone get 2 coins.

Each student counts a one radioactive atom.

When you flip the coins and get 2 heads, you decay and sit down.

Number of
undecayed atoms, N vs time, in number of flips

N (atoms or activity or mass)	time, t
N_o=24	0
18	1
13	2
11	3
10	4
6	5
5	6
3	7
2	8
1	9



$$N = N_0 \left(\frac{1}{2}\right)^{t/t_{1/2}}$$

← number of halflives

eg. Carbon 14 has a half-life of 5730 years (p621 in textbook)

a) if a sample starts with 5.0 mg of Carbon 14, how much will be left after 11460 years? how about 300 000 years?

b) If the sample has a fraction of the Carbon 14 of 1/32 left, how old is the sample?

p622 q9-12

a) 11460/5730=2

$(1/2)^2 = 1/4$

$N=N_o(1/2)^{\text{number of half-lives} = t/t_{1/2}}$

N=5.0 mg (1/4) = 0.25x5=1.25mg

300000/5730=52.356

(1/2)^52.356= 1.73×10^{-16}

$N=N_o(1/2)^{t/t_{1/2}}$

= 5.0 mg 1.80×10^{-16}

5.0x1.73=8.65

8.7×10^{-16}mg

b) 1/32 = 5 half-lives
so the time = 5x5730=28650= $2.9x10^4$years

Energy
Anti-matter can collide with the corresponding matter and annihilate - changes into gamma ray energy. Where did the energy come from? Where did the mass go?
Einstein famous equations $E=mc^2$ shows the relation between energy emitted and mass lost. Derived from his theory of special relativity, speed of light is absolute but there are no absolute frames of reference.

c is the speed of light in a vacuum, $3.00x10^8$m/s
m is mass in kg or MeV/c^2 or u
E is energy in Joules, J or MeV (mega electron volt)

1 MeV = 1.602×10^{-13}J

eg. An electron and positron both have the same mass of $9.11x10^{-31}$kg. If they meet, they annihilate into energy. How much energy? in Joules and in MeV?

p631 Q13
read p631-635 CR2.1-2.4

decay constant → $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

$$N = N_0 e^{-\lambda t}$$

$$\ln \frac{N}{N_0} = -\lambda t \qquad \boxed{t = -\frac{1}{\lambda} \ln\left(\frac{N}{N_0}\right)}$$

eg. ^{14}C $\lambda = \frac{\ln 2}{5730} = 1.2097 \times 10^{-4}$ s^{-1}

$$t = -\frac{1}{1.2097 \times 10^{-4}} \ln\left(\frac{1}{32}\right)$$

$t = 28650$ years

Radioactive Half-Life and Energy

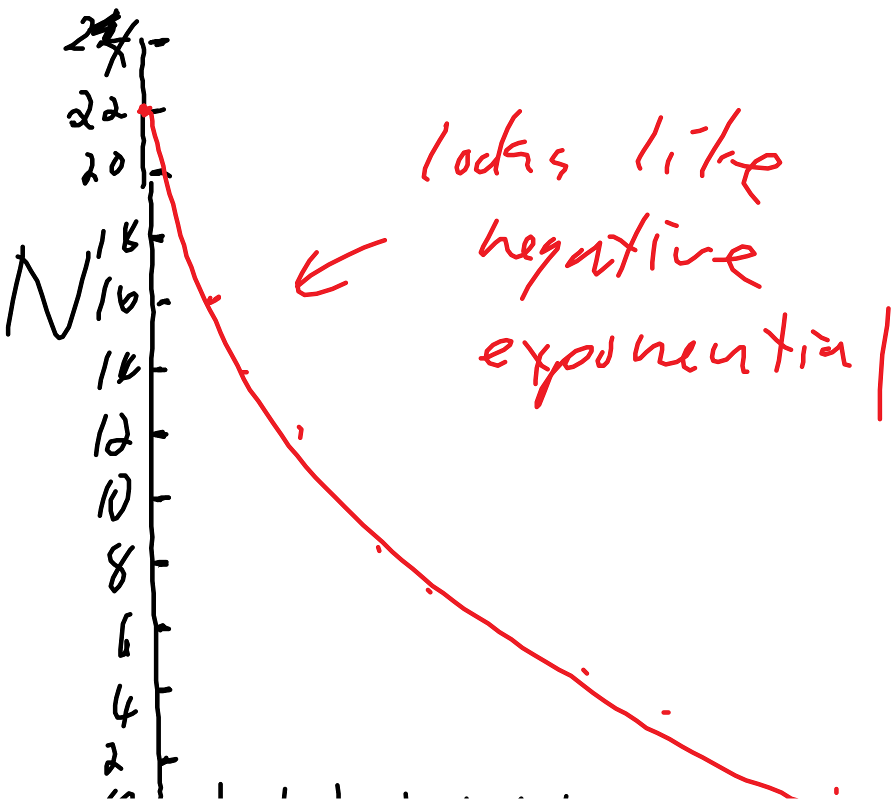
Last class, we talked about 3 types of natural

radiation, alpha, beta gamma.
alpha - Helium 4 nucleus
beta - electron and anti-neutrino or positron and neutrino emitted from nucleus
gamma - electromagnetic wave-pulses - energy

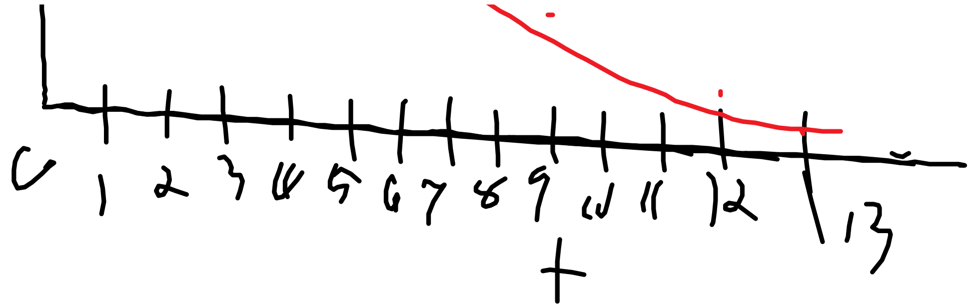
The decays happen randomly - we will model this by flipping coins.
N is the number of undecayed radioactive atoms
measure in number of atoms or mass or activity
N_o is the original amount of the sample, at t=0
t is the time, in years or seconds

in our model - N is number of students
t is measured in number of flips
if you get two heads, you have decayed and you sit down.

N	t
N_o=22	0
16	1
14	2
12	3
9	4
8	5
6	6
5	7
5	8
4	9
3	10



3	10
2	11
2	12
1	13



theoretical expression:
half-life is the time for half of the sample to decay on average.
symbol $t_{1/2}$
find in textbook on p 621
eg. carbon 14 has a half-life of 5730 years
Polonium 194 has a 0.7 second half-life
Plutonium 242 has a 3.79 x 10^5 year half-life

$N=N_o(1/2)^{\text{number of half-lives}}$
$N=N_o(1/2)^{t/t_{1/2}}$

eg. Carbon 14 has a half-life of 5730years. If you start with a sample of 5.0mg of Carbon 14,
a) how much would you have left after
i) 11460 years? ii) 300 000 years?
b) if you have 1/32 of the original sample of carbon 14 left, how old is the sample?

p622 Q9-12, p631 Q13, p635 CR 2.1-2.4

a) i)number of half-lives = 11460/5730=2
$N=N_o(1/2)^{t/t_{1/2}}$

$N=5.0\ mg(1/2)^2 = 1.25$ mg left

b) number of half-lives = 300000/5730=52.356

$N=N_o(1/2)^{t/t_{1/2}}$

$N=5.0\ mg(1/2)^{52.356} = 8.67 \times 10^{-16}$ mg

y^x punch in 0.5 hit y^x button then punch in 52.356 then multiply by 5

^ button?

c) $1/32 = (1/2)^5$

2x2=4 4x2=8 8x2=16 16x2=32 = 5 2s

5 half-lives, so

5x5730=28650 years

Where does the energy of the radiation come from? When matter and anti-matter annihilate, what happens to the mass?

mass gets changed into energy

Einstein's famous equation

$E=mc^2$

c is the speed of light in a vacuum, 3.00×10^8m/s

m is mass in kg, or MeV/c^2 or u - annihilated or lost

E is energy in J or MeV released

MeV is mega electron volt - a unit of small energy

1 MeV = 1.602×10^{-13}J

eg. if an electron and positron annihilate, how much energy is given off as gamma rays? answer in J and MeV mass of the electron is 9.11×10^{-31}kg, the same as a positron